

trician, than is evidence furnished from the antipathetic standpoint of those interested solely in telephones.

(b.) The evidence in favour of the single-trolley system is explained by the fact that it is the system most generally used. The evidence and authorities given by Mr. Baron conclusively prove this.

(c.) The double-trolley system is not so well adapted to steep grades, as exist in Dunedin, or for turning corners, as the single-wire system; as the double trolley more easily gets out of gear, with the result that, if it does so in one part of the line, all the cars all over the line have to come to a standstill.

(d.) I would here quote from Crosby and Bell's book, pages 142 to 144 :—

"Except in the matter of the rail-and-earth circuit, all that has thus far been said applies equally well to the single- and double-trolley systems. The latter has now been almost wholly superseded by the former. There are three reasons for the survival of the single-trolley method as the fittest: First, greater simplicity of overhead turn-outs and frogs, in so far as the mechanical operation of the trolley is concerned—and this is the controlling reason; second, greater facility in insulating the out-going from the in-going side of the circuit, for, when the rail-return is used, these sides are about 18ft. apart, while with the double-trolley wire they are from 8in. to 18in. apart; third, greater economy of copper in large systems. This advantage is not as great as has appeared from the comparisons already given in discussing the copper calculations. An offset must be made by considering the cost of bonding the rails thoroughly, as compared with the cost of supplying and erecting the copper return, which would serve instead of the rails and earth. In case of very light service, the first cost may be less for the double- than for the single-trolley system. A fourth advantage is usually claimed, in that fewer wires are actually required to be erected, thus diminishing the objections made to the whole trolley system merely on the score of 'looks.' To this, the advocates of the double-trolley (for there are a few) answer that in either system all feeder wires may be buried; that the comparison would then rest as between bare wires alone; that the single-trolley wire requires one or two guard-wires, stretched parallel to each 'live' wire, and these guard-wires require span-wires for their support—this being done to prevent foreign wires from falling across the 'live' wire and to the ground, where they may or may not make such contact as will cause them to be entirely burned out; that the double-trolley system does not require guard-wires, since, in case of any foreign wire crossing the two 'live' wires, it would be at once destroyed, and the trouble at the railway-station would end.

"There has been so little extension of this double-trolley system that it cannot now be stated whether or not the public authorities would generally allow this difference of construction as between the two systems. It does not seem probable. In Cincinnati, Ohio, where the Cincinnati Street Railway Company has produced the most notable example of double-trolley service, guard-wires were however not erected.

"The advantages of the double-trolley system are two: First, it causes little interference with the telephone circuits that use ground returns in the neighbourhood of the railway lines. This has been the cause of much litigation, urged by the telephone interests, endeavouring to force the use of that system of electric railways which would least interfere with the established telephone service. Thus far, the Courts have ruled, for the most part, against such requirements.

"The case of the telephone labours under this disadvantage: that it strives to destroy the most practical system of railway circuits in order to continue a relatively poor system of telephone circuits. The remedy for the evils brought upon the telephone service by the disturbing earth-currents of the railway service is to be found in the use of complete metallic circuits for the one or the other or both. To apply the remedy to the telephone circuits is to produce the only installation which may be called first-class, with or without consideration of railways. The currents required for telephones are exceedingly small; the forces by which they may be disturbed are correspondingly small. To insist that, when passing through the earth, these currents shall not be perceptibly disturbed by other currents, is to insist upon a practical monopoly of the earth as part of an electric circuit. The best English and European telephone practice, uninfluenced by any trouble from railway currents, tends decidedly towards complete metallic circuits. To apply, on the other hand, the same remedy to the railways, is to impose serious difficulties in the way of the practical success of the operation of cars over the complexities of switches, turn-outs, cross-overs, and the like.

"We cannot do better, in setting forth more fully the merits of this controversy, than to give the opinion of the Superior Court of Cincinnati, and the Supreme Court in the State of Ohio. These are found in Appendix E.

"The second advantage to be noted is this: that effective insulation of the motor-windings may be more readily secured than in the case of rail-return circuit. In the earlier stages of the art this was indeed an important advantage, for on the single-trolley roads no accident was more common than the 'grounding' of armature of field-coils. Previous practice in winding for comparatively high potentials had rarely to deal with the case in which the metal of the machine was in fact part of the circuit. To produce a short circuit through the body of the dynamo it was generally necessary that the insulation of the wires should break in at least two points of different potential. When, however, one brush of the motor was connected, as was often the case, directly to the motor-frame (this latter being hung on the axle, whence the current passed through the wheels), it needed a break at but a single point to cause trouble. In the violent fluctuations of current-strength and magnetic density incident to car-service there were often produced very high electro-motive forces of induction, and these, if not the normal pressure of 500 volts, often destroyed the insulation of armature or field. In some designs this trouble has been practically met by attempting to insulate the frame of the motor from the car-truck. This will be seen to impose considerable mechanical difficulty. Generally, so much improvement has been made in the details of armature and field-winding that the matter has ceased to be big with misfortune, as was once the case.